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Review

Quantitative Models of Well-Being to Inform Policy: Problems and Opportunities

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Abstract: Subjective well-being, in contrast to other commonly used performance metrics such as gross domestic product, appears to offer a way to directly measure what society aims to achieve. Subjective well-being modeling to date has been restricted to regression analysis. This paper synthesizes and critiques existing literature and case studies to examine the challenges and opportunities presented by more advanced computations of well-being, including spatial, optimizing and spatial-optimizing models, which may well be created by researchers in the future if current policy level interest in well-being continues to grow. Subjective well-being is a promising measure, especially in light of recent research that shows reliable correlations with objective measures. However, the issue of individual adaptation means that excessive focus on subjective well-being may discriminate against groups with lower expectations and higher ability and/or willingness to adapt. Alternative approaches such as equivalent income may address this issue, at the expense of being harder to measure. Through an examination of four case studies and one thought experiment, we find that modeling challenges include nonlinearity, interaction, spatial sorting and extrapolation beyond valid limits. A significant research gap is found in how individual well-being scores should be aggregated to a collective one; this is a normative question although descriptive ethics would appear to offer a practical approach.

Keywords: well-being; subjective well-being; modeling

1. Introduction

Governments and urban planners have long used quantitative models to inform the decision-making process, including optimizing models in transport and spatial models in economics, while academic research experiments more widely with these model types. While most such models are used to compare different options for future developments—with cost-benefit analysis typically used to select options with the highest cost–benefit ratios—a more recent trend primarily confined to academic research is the automatic optimization of a specific outcome measure or multiple measures in a multi-objective trade-off framework [1–4]. Whether automatically optimized or not, all such models rely on metrics with which to evaluate plans: quantities we aim either to increase or decrease.

With the benefit of hindsight, the measures chosen in the history of policy modeling have not always helped. A well-known example is that of early transportation planning, which initially took road congestion as the measure to be minimized. It took decades to realize that decreasing congestion simply encouraged greater use of private cars, often resulting in return to an equilibrium state of congestion. Congestion was eventually discarded as an outcome measure in the UK [5], and the Department for Transport now considers trade-offs between various forms of cost and benefit—for example air pollution and climate emissions, health, time savings, economic productivity and the monetary costs of the development itself—within a framework of welfare economics [6].

It is worth asking whether the current paradigms for the computational simulation of urban systems risk falling into the same trap as the 1950s transport planners who directed their efforts

towards reducing the wrong measure. But what would the correct measure, for all models and all fields of application, ultimately be? The current well-being research agenda—intent on directly measuring subjective well-being (SWB)—may offer an answer to this. Yet SWB as an outcome appears to be under-explored in existing spatial planning frameworks [7] with proxy goals such as land use diversity [8], quantity of green space [9], accessibility and noise pollution [10] being used in its place.

The contribution of the current paper is to synthesize and critique existing literature and case studies to explore existing application of SWB in regression models, and the possibility of its application to spatial, optimizing and spatial-optimizing models. A gap is found in the descriptive ethics of SWB inequalities; the author hopes to make the case that this must be addressed if computational models are to effectively aggregate individual level to population level SWB outcomes. SWB is also found to be limited by the issue of individual adaptation, so may not be the most appropriate target measure for all models; the alternative approach of equivalent income, which avoids this issue but is harder to measure, is discussed. Whichever route is taken, modeling SWB is challenging due to strong interaction terms, spatial sorting effects and the potential for exceeding the limits of valid extrapolation unless capabilities are also modeled.

The remainder of the paper is structured as follows. Section 2 introduces the measure of subjective well-being and discusses limits of the contexts where it might appropriately be applied. Section 3 discusses more fundamental limitations to SWB: the problems of adaptation and aggregation. Section 4 covers alternative approaches that may partially address both of these problems, while Section 5 outlines a research gap in the use of descriptive ethics to solve issues of aggregation. Section 6 draws some lessons from existing well-being models, and Section 7 concludes.

2. The Importance of Subjective Well-Being and Limits to Its Context of Valid Application

Of the many types of SWB defined in the literature, the prevailing assumption is that life satisfaction represents the closest measure to the economist's notion of utility [11]. This is measured by asking a question similar to

> "On a scale of 0 to 10, where 0 is "not at all" and 10 is "completely" [. . .] Overall, how satisfied are you with your life nowadays?" [12]

Possibly augmented by also asking about the respondent's expectation of their answer in, say, five years' time. The first question of many newcomers to SWB might be to ask why such a seemingly obvious approach has only recently come into vogue. The reason likely has its root in traditional scientific distrust of subjective measures, which has gradually been overcome as the weaknesses of more objective alternatives became apparent. Gross domestic product (GDP), for example, has long been used as a measure of how well a nation is performing, though it has recently fallen out of favor due to (1) its failure to capture externalities such as environmental and social impacts; (2) an artificial inflation of GDP by speculative trading of assets with a nominal value unrelated to productivity; and (3) the growing recognition that, for richer nations, further increases in wealth may not be reflected in increased well-being [13–15]. SWB, by contrast, appears to strike directly at the heart of what we want society to achieve [16]. We are thus presented with a substantial opportunity to measure and optimize what appears to be, within sensible limits, the only measure that truly matters; this cannot be overstated.

The first round of objections to the validity of the SWB approach focused on questioning whether respondents all interpret the subjective scale in the same manner. However, although measurement of SWB appears to rely on an assumption of individual rationality (which a large literature on cognitive bias tells us is unwarranted), SWB has been demonstrated to correlate reliably with many objective measures, such as age [17], income [18], genetics [19], relationships, discrimination against sexual minorities [20], parenting [21], employment and health [22–24], innovation [25], living arrangements [26,27], migration [28,29], empowerment [30], environment [31] and mixtures of all the above [32] (although a reviewer of this paper notes a research gap in the meta-analysis of studies of this

nature). SWB is also less susceptible than might be thought to measurement bias caused by differences between nations and cultures [33].

The broadest limitation of well-being as a policy aim stems from the basis of well-being in utilitarianist ethics [34]. This applies both to the narrow sense of utilitarianism—an attempt to maximize total good—and to a broad sense that also considers how that good is distributed between people, i.e., "the greatest good to the greatest number" (this definition is left deliberately imprecise for now, but refined in Section 5). Objections on this level are better illustrated by popular fiction than any academic paper. Narrow utilitarianism allows, for example, punishment of the innocent to serve the greater good: Ursula K. Le Guin in *The Ones Who Walk Away from Omelas* illustrates that a violation of human rights causes us to question the appropriateness of maximizing average individual utility. On the other hand, a broader definition of utilitarianism can lead to an endorsement of Huxley's *Brave New World*, where genetically-engineered members of society sacrifice personal freedom in exchange for well-being induced by mood-altering drugs. Even if such a choice were both possible and voluntary, it is not widely considered an acceptable state of affairs. We will not discuss these examples further, save to suggest that neither need undermine the well-being agenda, but both outline some of the limits to the context in which it is valid.

Within these limits, it still seems reasonable to take the increase of well-being as an aim, if not our overall one: even climate change can be framed as a well-being issue, including the well-being of other species if so desired (and in any case, shifting from economic growth to well-being as an outcome metric is likely to be a win-win for both well-being and climate). Indeed, framing climate in this way is the approach taken by the Welsh Well-Being of Future Generations Act [35]. That said, from a modeler's perspective, until a more precise emissions-vs.-future-well-being relationship can be established, we can only conclude that enormous effort is required to meet scientifically agreed targets for emissions, and it is likely necessary to present climate risk and current well-being as dual outputs within a multi-objective framework. These frameworks discard sub-optimal (lose-lose) solutions while maintaining a set of non-dominated (win-lose) solutions, which cannot, within the confines of the model, be ranked as objectively better or worse than one another. They are thus the natural choice for unifying quantitative urban models [1–4]; and with thoughtful presentation also offer valuable opportunities for public engagement [36]. (Multi-criteria optimization is also rightly known in some literature as Pareto optimization; the current paper avoids this term to prevent confusion with the notion of Pareto optimality in economics, which while mathematically related, is a distinct application in a political context not relevant to our discussion).

3. Adaptation and Aggregation: Fundamental Limits of Well-Being Modeling

A different class of difficulty from the perspective of the modeler and policymaker is the dependence of individual well-being on the individual's ability or even willingness to adapt. This is well expressed by Frey and Stutzer [37]:

> Extreme and well-known examples are paraplegics who after a time of hardship in the long run report themselves to be only a little less happy than before, and lottery winners who after a short period of elation report themselves to be not much happier than before [. . .] Let us consider the case where courts have to decide about compensation for losses suffered in a car accident. For the same physical harm, should they award lower damages to people with a strong capacity to adapt and higher damages to others? [. . .] Materialists with high income aspirations suffer a great deal from personal income taxes. Should they be exempted from tax?

The examples cited outline pitfalls in making individual-level decisions based on SWB, which is not generally the role of urban modelers. However, there is no guarantee that such pitfalls can be avoided even at the aggregate level. If expectations and the ability and willingness to adapt are in any way correlated with other sociodemographic characteristics, then policy shaped on aggregate SWB

research will suffer from omitted variable bias, leading to systematic neglect of the demographic with low expectations and high adaptability. Although expectations are in principle measurable, and have been used to explain some empirical results [38], there is no obvious way to measure or even define the difference between ability and willingness to adapt, so this problem remains at large (and if ability and willingness to adapt are one and the same, then the problem extends beyond well-being and into human ethics in general).

A related problem is that individuals have an incentive to report lower levels of well-being, if they believe that such reporting may lead to them later being accorded some additional benefit by policymakers seeking to redress it. Unlike financial income for instance, SWB reports cannot be independently verified (except perhaps pending future innovation in neuroscience). This offers a further reason to keep SWB at least partially decoupled from policy decisions.

A final limitation of the policy of maximizing SWB is of course the question, "whose well-being"? Alternatively, what is the correct means for aggregating individual well-being scores to determine the overall well-being of a society? The problem of aggregation echoes the issue of how to aggregate "welfare" in the eponymous field of welfare economics, which we discuss in the following sections.

4. Alternatives to Subjective Well-Being as an Outcome Measure

Here we expand on the final above-mentioned limitation of the policy of maximizing SWB, by exploring its relation to the core problem of welfare economics, which, although predating the SWB research agenda, advocates the maximization of a social welfare function. But how to define a function which aggregates individual level preferences, welfare, or SWB to a collective utility score, when Arrow's [39] Impossibility Theorem proves from seemingly reasonable assumptions that it is impossible to do so democratically?

The remainder of this section summarizes and critiques Decancq et al. [40] by considering two alternative approaches presented in that paper in the context of the current discussion. The first of these—the capability approach—has largely eclipsed welfare economics in recent years, leading to the United Nations' adoption of the Human Development Index [41], and the OECD Better Life Index [42]. It consists of defining multiple capabilities people must have in order to engage in their personal pursuit of happiness (life and liberty, as per the US Declaration of Independence, being among them); and aiming to provide all said capabilities. The popularity of this approach speaks for itself, but we could criticize it on the grounds that these measures are on some level necessary, but not sufficient, conditions for well-being. Once again, therefore, to limit well-being measurement to capabilities risks measuring outcomes that are important, but not directly reflective of the ultimate aim.

The second alternative approach is the notion of equivalent income (EI). To define this measure it is first necessary to define a "reference individual"—a hypothetical person who is, for example, in good health, single, works a 37.5 h week, etc. A survey respondent's equivalent income is then defined as the answer to the following question: "What level of income, if your characteristics matched that of the reference individual, would give you the same satisfaction as your current situation?" [43]. Thus, someone with ill health might reply with a low or even negative EI if they desire to trade wealth for health, while someone who has no need or desire to work might respond that it would take a very high EI to entice them into the workforce. Note that this solves the problem of adaptation raised in Section 3: the first respondent will still give a low EI even if they have adapted to their circumstance, while the second will still give a high EI even if they have high aspirations and expensive taste. It also solves the issue of comparability: though it may be worth more to some individuals than others, a dollar will usually buy the same quantity of goods no matter who holds it, in contrast to a given point on the subjective well-being scale, which may mean different things to different people.

The choice of a reference individual (RI), however—including the question of what is left unspecified—is crucial. Decancq et al.'s paper raises a number of technical issues surrounding this point, and is recommended reading for anyone using the EI approach. Here, we raise a new point surrounding the difficulty of measuring EI with the following example. Suppose a survey respondent

is in a demographic subject to racial discrimination. If the RI, unlike the respondent, hails from the country's ethnic majority, then the respondent is being asked to quote a price for being divorced from what might be a core aspect of their own identity—and it is unclear whether a meaningful EI could be obtained by survey, or whether alternative techniques must be devised. On the other hand, if the RI is of an unspecified demographic, then EI will fail to capture widespread differences in well-being caused by discrimination. Further problems arise in cases where preferences vary: consider the question of whether the reference individual should or should not have children—a characteristic that gives rise to different income requirements as well as changes in well-being moderated by personal preference. Computing a minimum EI over multiple RIs would be one approach to the latter issue.

As an interesting aside, Decancq et al. contrast how all of these approaches handle Arrow's impossibility theorem. Capabilities respect the theorem as it stands, by eschewing the ranking of the relative desirability of various societal outcomes altogether in favor of defining a number of minimum acceptable standards. SWB and EI succeed by virtue of relaxing Arrow's assumptions: in the case of SWB, the assumption—whether or not justified—is that measures of preference are not comparable between individuals; and in the case of EI, the assumption is that the relative desirability of two alternatives should only depend on the two alternatives under consideration (the reference individual constitutes a third alternative).

In summary, both the capabilities and equivalent income approaches solve the scope, expectation and adaptation problems inherent to SWB by defining a set of life attributes (liberty, health, etc.), which by consensus it is not unreasonable for an individual to desire. However, the capabilities approach requires consensus on the relative value of each of these attributes, which its advocates have been unwilling to define (ibid.), while equivalent income presents issues with the choice of the reference individual and measurement. Decancq concludes that the choice between SWB, EI or capabilities is a normative issue based on the desired degree of respect for individual preferences, and where the boundaries of individual responsibility are drawn (this itself is a political question we return to in Section 7).

5. The Problem of Aggregation

Given the history presented above, we now return to the problem of aggregating individual to collective measures, whether defined by equivalent income or subjective well-being; the discussion assumes the latter approach, though for the most part applies equally to the former. We follow the welfare economic tradition in referring to the aggregation algorithm as a social welfare function (SWF). The problem of aggregating well-being measures was discussed by Bronsteen et al. [44] though left unsolved (the authors merely note that this issue is not unique to subjective well-being as it also applies to cost–benefit analysis).

The narrowly defined "utilitarian" SWF simply computes total utility by averaging the well-being of all individuals to determine the well-being of society (whether or not simple addition of SWB scores is a valid approach is a topic we return to below). At the other end of the scale, the Rawlsian SWF defines the well-being of society as being equal to the well-being of its worst-off member [43]. The choice of SWF therefore encodes a normative decision on equity, but both of these appear to represent extremes which may not be accepted by the average individual: although the Rawlsian stance is a commonly expressed sentiment, it may well be abandoned when faced with a choice between slightly improving the well-being of the worst-off individual vs. greatly improving the well-being of many near-worst-off individuals.

A definition of a social welfare function is necessarily dependent on personal views on what constitutes an acceptable level of inequality in subjective well-being. Here, there appears to be a considerable research gap in descriptive ethics: can we not survey public opinion on this very question?

An excellent example exists that was applied to the question of wealth inequalities: Kiatpongsan and Norton [45] surveyed public opinion on the "right" level of CEO pay. Although thought provoking, in a polarized political environment this study is subject to criticism on the grounds that most

individuals are not well placed to understand the executive compensation market, nor to model any efficiency–equity trade-off that might bear on the question. The efficiency–equity trade-off is an old topic in economics—in financial terms, for wealthier countries, the beneficial effect of further efficiency on well-being has been called into significant question [15]; however in the well-being domain this trade-off remains under-researched (Praag [46] considers issues of equity absent of this trade-off, while Layard [47] explores the trade-off, albeit absent of empirical data on preferences).

Returning to our question of the descriptive ethics of well-being, taking a similar approach to Kiatpongsan and Norton, albeit applied to well-being rather than pay, might well address the obvious criticisms of that study: firstly, because a 0–10 scale of well-being is perhaps more comprehensible to all respondents than a discussion of pay scales they have never experienced, and secondly, because the efficiency–equity trade-off, whether or not its effects are significant in the well-being domain, can in any case be incorporated into the survey design. Flexible and discrete choice stated preference modeling, as is currently used to predict individual decisions in transportation (http://www.choice-metrics.com/) [48,49], may offer a tool capable of determining, from a survey, suitable utility coefficients for a model predicting accepted levels of trade-off between average well-being and well-being equity. From a participant perspective, the survey would likely involve numerous choices of the style presented in Figure 1, making use of the philosophical "veil of ignorance", whereby the designer of a society does not know which body they will ultimately inhabit (though this concept has a long history from Thomas Hobbes to Immanuel Kant and John Rawls [34]). Results are likely to differ according to the culture of participants; cultural influence can be captured via, e.g., the Hofstede [50] model.

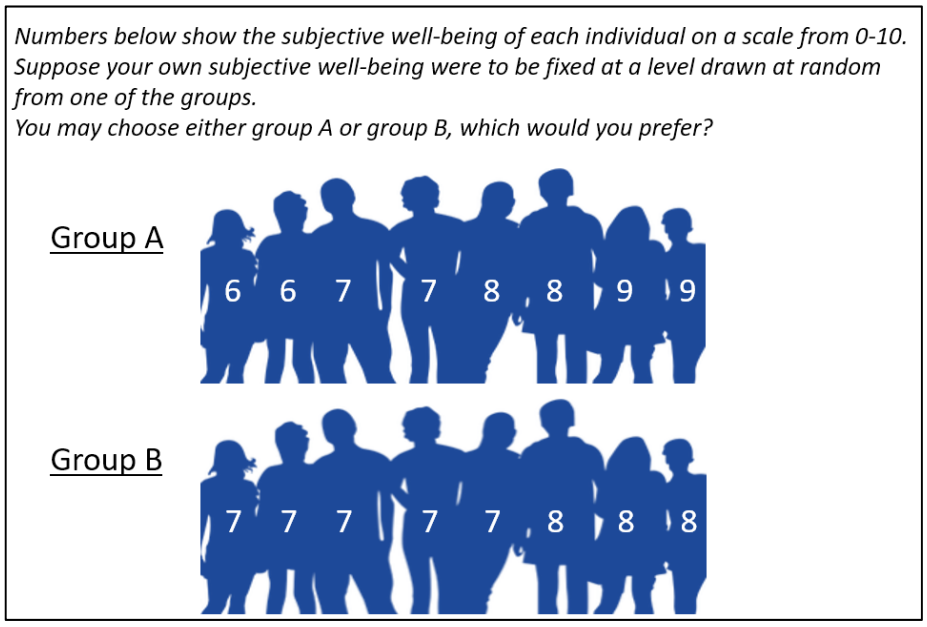

Figure 1. Sample question from survey designed to elicit public preferences on a social welfare function for subjective well-being (SWB).

In addition to answering questions of social equity, this descriptive ethics exercise would also directly answer questions on the relative utility to individuals of different points on the well-being scale. Is the relationship between well-being and utility linear—is an increase in well-being score from, say, 7 to 8 "worth as much" as an increase from 5 to 6—in other words can we simply add or average individual SWB scores to calculate utility, in the narrow sense of total good [51]? Layard et al. [18] estimate that SWB is, in fact, approximately linear with mild compression at the top end of the scale (9–10 being worth slightly more than 7–8), though they reach this conclusion via diagnostics on an income–SWB regression model, and more reliable results would likely be obtained via direct measurement.

6. Modeling Well-Being: Examples and Lessons

Once a suitable social welfare function has been defined, it is possible to run automatic spatial-optimizing models of well-being. To the author's knowledge, nobody has yet done this. Various regression-based SWB studies exist, however, which implicitly embed a social welfare function, and which point towards issues that must be resolved in future modeling efforts. The current section discusses four such studies in a UK context, and concludes with a thought experiment on what an automated optimizing well-being model might look like.

6.1. Case Study 1: Regression Analysis of All SWB Responses

The usual approach to a quantitative well-being model appears to be ordinary least squares (OLS) or ordered probit regression. Oguz and Merad [52] provide an example of both in an analysis of the first well-being data release from the UK Office for National Statistics. Key findings are that the most significant predictors of well-being are being healthy, not unemployed (i.e., it is preferable to be either employed, retired or in education), and in a relationship. Any policy based on these results, however, would reflect the assumptions embedded in the regression: firstly, that social equity is irrelevant, because coefficients are computed based on their effect on the total level of well-being; secondly, that utility is a linear function of well-being.

6.2. Case Study 2: Predicting Outliers

Pyle and Manclossi [53] provide a contrasting example, addressing the question "Who has the poorest personal well-being?"—therefore implicitly embedding a Rawlsian social welfare function. Results show poor well-being to be associated with poor health, economic inactivity, middle age, lack of a relationship, rented accommodation and lack of education. Furthermore, strong interactions are found for combinations of terms: economically inactive with long-term illness or disability, unemployed or inactive renters with self-reported health problems or disability, employed renters with self-reported health problems or disability, and retired homeowners with self-reported health problems or disability. This illustrates a key lesson in well-being research—that interactions between predictor variables have strong effects and should be considered in any model. For example, access to green space is known to positively influence well-being [54,55] but capacity to make optimal use of the same is limited by disabilities.

6.3. Case Study 3: Treasury Policy

The UK Treasury Green Book [56] outlines the process for cost–benefit analysis used by the government. The methodology is based on welfare economics and thus prices in externalities, such as health and pollution effects alongside direct financial impacts. A study by Layard et al. [18] is cited to justify policy in terms of well-being outcomes. As cost–benefit analysis used to prioritize allocation of a limited budget is itself a form of manual optimization model, we can therefore consider the Treasury policy to incorporate a well-being model and evaluate it on those terms.

Layard et al. demonstrate the nonlinear relationship between wealth and well-being by computing an elasticity of 1.3. The policy aim is to maximize projected benefit by summing benefits minus costs, but based on Layard's findings a multiplier of 2.5 is applied to projected income benefits to low income groups (the income measure used is in fact equalized income; although this sounds similar to the equivalent income approach discussed in Section 3, it is restricted to consideration of financial needs for different household structures, and excludes other determinants of well-being). Two lessons can be drawn from this:

1. That nonlinear relationships, such as that found by Layard et al., are important in SWB models.
2. The policy as stated effectively embeds a social welfare function appearing to encode a moderately redistributive policy, which in financial terms lies somewhere on the spectrum between Rawlsian and narrow utilitarianism. From a well-being perspective, however, the interpretation is narrow

utilitarianism: maximizing total benefit, even while correcting for the nonlinear wealth–SWB relationship, is tantamount to prioritizing low income groups not for reasons of equity, but because it is literally cheaper to "buy" well-being for low income individuals than to buy it for anybody else. If any ethical stance other than "strict utilitarianism in SWB" is to be represented, then further redistribution of income is needed.

6.4. Case Study 4: Spatial Models of Well-Being

Initial publication of the UK Office for National Statistics' well-being results [52] shortly led to national headlines reporting that residents of the Outer Hebrides islands—some of the most remote and least urbanized places in the UK—experienced the highest levels of well-being overall. This was followed up with the spatial well-being model of Oguz [57], which illustrates further issues that must be accounted for in well-being. The less-reported outcome of the latter was that spatial characteristics showed a diminished effect when personal characteristics were taken into account—in other words, a substantial portion of the spatial effect was explained not by the place, but by the people who lived there (a result replicated for Hong Kong in [58]). Still, these results are not conclusive, as they beg the question of who lives there and why: a spatial sorting process has taken place through residential location choice, and to sample a group of people who have already been subject to such sorting will lead to biased results. If high well-being people are intrinsically more likely to move to the Outer Hebrides, then we can argue that the place is irrelevant; conversely, if the well-being of people who moved to the Outer Hebrides was contingent on them moving there, then the place is important after all. Generalizing from this example, although research exists on the well-being effects of (motivations for) relocation [29,59], spatial models of well-being are likely to be incomplete unless we first succeed in modeling residential location choice—based on factors that likely include aspirations and age—and then ensure these same factors are included in the well-being model. Established agent-based residential location choice models may be suited to this task (http://silo.zone/hhRelocation.html; http://www.urbansim.com/urbansim/) and, as people typically also spend time in places other than their home location, time use models may also be suitable [60,61]. The importance of modeling at the level of the individual has long been acknowledged in epidemiology, and agent modeling may well have further application here. Individual level modeling is an achievable aim, though it does necessitate the use of personal data and the associated cost of using robust measures to protect the privacy of individuals.

6.5. Thought Experiment

Finally, we consider what an automated spatial-optimizing model of well-being might look like. The example relates to the urbanization agenda, at both the national and global scale: climate issues aside (or addressed in a multi-objective model as discussed in Section 1), can we determine an optimal pattern of spatial development for well-being? We will include the four factors below—as the example only serves to illustrate the discussion, we will assume that all effects exist and that the model is complete, although in practice any effort such as this should begin with a series of stakeholder workshops to determine the factors for inclusion:

- The green space–well-being link [54,55,57];
- The wealth–well-being link: acknowledged to be important in lower income countries where additional wealth directly translates into satisfaction of more capabilities, though of lesser importance in high income countries where studies estimate that relative income and wealth (i.e., income and wealth compared to other citizens) potentially account for the majority of the relationship [62,63];
- The spatial agglomeration–wealth link [64]: although the level of this varies by industry sector [65] if it exists at all [66];
- Residential location choice.

From these premises we note a tension between increased green space for well-being and increased urban agglomeration leading to increased wealth and hence well-being—an obvious candidate for an optimization approach. Further consideration, however, reveals that an optimization search may push a wealth–well-being model calibrated to existing data far beyond the limits of valid extrapolation. For example, we have no current data to describe how UK citizens would cope with, for instance, disbanding all cities: a valid portion of parameter space for an optimizing model to explore, but which—*if* the spatial agglomeration–wealth link holds—would risk dramatic changes including loss of the revenue stream that funds health services currently taken for granted. This serves to highlight the importance of the capabilities-based alternative to well-being modeling discussed in Section 4, which may provide an approach to evaluating the extreme edge cases reachable during optimization.

7. Conclusions

Subjective well-being offers, if not a way to measure what some might argue is the only thing that truly matters, at least a path towards that objective. Although the bulk of this paper is dedicated to problems with SWB-based models, the fundamental underlying opportunity is hard to over-emphasize, and the author's intention is certainly not to counsel against the use of SWB but rather to inspire efforts to tackle its limitations. In sum:

1. SWB should be used with great caution, as issues of adaptation can cause systemic bias against groups with lower expectations and groups more willing or able to adapt. The Equivalent Income approach offers an answer to this issue, but presents further issues with choice of reference class and may not be as simple as SWB to measure by survey. Defining a suitable SWB-like metric that resolves all of these problems is an unrealized, but perhaps not intractable, aim.
2. The path to modeling any SWB-like metric is beset by strong nonlinearity, interaction between predictor variables, and spatial sorting effects. Optimization models could potentially stray beyond the limit of sensible extrapolation from current data, a problem for which explicit modeling of capabilities may present a partial solution.
3. SWB-like metrics reported at the population level will inevitably encode a social welfare function for aggregating individual-to-population-level scores. This choice should be made explicitly rather than be determined as a side effect of the methodology used (for example, OLS regression or cost-benefit analysis). Ultimately the choice is a normative one, but descriptive ethics may offer an avenue towards social consensus.

As always, socio-economic research is also shaped by politics. Rose [67] outlines a political context in which well-being is seen as an individual level problem, and structural issues affecting it are ignored. Although the existence of state-sponsored research that identifies structural barriers to well-being serves as a counterexample [53], Rose argues that the usage of well-being concepts in research itself will shape this relationship in the future, one way or another. The issue of accountability and transparency of algorithmic models also prevails.

A reviewer of this paper notes uncanny relevance of this discussion (written mid-2019) to the subsequent coronavirus pandemic. One key difference between Section 5's thought experiment and the ongoing situation is that the current death toll stems from short-term healthcare capacity limits, rather than reduction in future healthcare investment caused by economic recession. Much though we may wish otherwise, it is certain that the pandemic will provide unprecedented data to inform future models. The UK government's response also illustrated a wealth–well-being trade-off applied in practice that was widely criticized [68] and followed within five days by an apparent reversal of policy reflecting a more cautious approach with greater prioritization of life and health for those with severe symptoms [69]—in the context of this paper, a step towards the Rawlsian social welfare function. Debate on what would have constituted an optimal approach is not likely to end any time soon.

By way of conclusion we would do well to remember Goodhart's law: "When a measure becomes a target, it ceases to be a good measure" [70]. As discussed in Section 2, this undoubtedly applies to the

prevailing national measure of productivity, GDP: while direct gaming of GDP does not appear to be a significant issue, the measure could perhaps be viewed as subject to collateral damage from perpetual attempts by individuals and institutions to game the legal and financial systems. Notable examples are the mis-valuation of collateralized debt obligations leading to the 2008 financial crash, the LIBOR rates scandal which rose to prominence in 2012, and long-term lobbying by polluting industries against Pigouvian taxes to compensate for the negative externalities of their business. It would be naïve to presume that well-being, being non-monetary in nature, will be immune to similar antics: if resources are increasingly allocated based on projected improvements to well-being then the incentive to game metrics is inevitably present. We can only hope to avoid the SWB crash of the 2030s! On the other hand, attempts to eschew measurement altogether can only lead to an unconscious choice of measure. Given the necessity of choosing something, the author believes that cautious use of SWB-like metrics—and ultimately, developing a future metric that addresses their current issues—represents the most promising way forward.

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